

NASA TECH BRIEF



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High Temperature Alloy

The problem:

Electrical power generators, aerospace propulsion devices, and similar applications, because of repeated operation at high temperatures over long periods of time, often require, as structural materials, alloys which are initially strong, weldable, and formable into a variety of mill products, such as tubing, sheets, etc. These alloys also must be oxidation-resistant at high temperature and must be structurally stable, i.e., able to retain their mechanical properties after high temperature exposure. Generally, cobalt-based alloys have been used in applications of these types. In the past, these alloys have had one major deficiency. This has been their susceptibility to embrittlement or loss of ductility upon prolonged exposure to high temperatures. As structural failure must be avoided, this problem establishes an environmental limitation on the use of prior art alloys. Thus there has been a need for an alloy of the type described which could withstand prolonged exposure to high temperatures without loss of ductility.

The solution:

An alloy (S-1) which is capable of being formed into various mill products, such as tubing and sheet, is capable of being welded, has good high temperature strength, and is not subject to embrittlement produced by high temperature aging.

How it's done:

This was accomplished by utilizing a basic alloy and substituting molybdenum for tungsten on an atomic basis. It has been found that the high temperature aging of high strength cobalt-based alloys is associated with the precipitation of certain metallic carbides and intermetallic compounds of cobalt and tungsten. These metallic carbides are generally represented as M_6C and $M_{23}C_6$ while the intermetallic com-

pounds which appear to be most detrimental are Co_2W types.

By replacing part or all of the tungsten with molybdenum, and by limiting the tungsten and carbon contents to less than 7 and less than 0.07 percent, respectively, the characteristics of this alloy (S-1) closely match the characteristics of prior art high-strength cobalt-based alloys, but are notable for the absence of any tendency to embrittle on heat aging above 1000°F.

Forming of an 0.5-inch thick, S-1 alloy plate into a cylinder was performed at room temperature. Welding and machining operations were performed with ease equal to that normally encountered with standard alloys.

Note:

The superior ductility retention of this alloy (S-1) became more clearly evident after aging for 1000 hours at 1600°F, when it was found that elongation had still remained at about 30 percent. By comparison, prior art high-temperature cobalt-based alloys have an elongation of about 12 to 19 percent after aging for 100 hours and 6 to 11 percent after aging for 1000 hours.

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457 (f)], to the General Electric Company, Missiles & Space Division, Cincinnati, Ohio.

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of General Electric Company
under contract to
Lewis Research Center
(LEW-10377)
Category 03